Title: Heart Rate and Physical Fitness

Brief Overview:

> The effect of microgravity on the cardiovascular system is one of the main concerns of space travel. The physical fitness of astronauts is important for many reasons, but the strenuous conditions put on the heart during space travel is among the top. In this activity, the students are able to test their own physical fitness, as well as see the effects of physical exertion on the heart rate.

NCTM 2000 Principles for School Mathematics:

- **Equity:** *In this activity, the expectations for each student are the same. Although students will be working in groups, they play both the role of tester and subject. A thorough knowledge of the procedures is required of each student.*

- **Curriculum:** *The curriculum for this course is designed around basic biochemistry and statistics principles. The students begin with background activities and lessons, and then apply these skills to several statistics activities and microgravity experiments.*

- **Teaching:** *Before the students even begin with statistics, they are introduced to the basic concepts necessary to understand how they will perform each statistical test. They are then able to apply these basic concepts to experiments they have performed in the laboratory setting.*

- **Learning:** *During the course, students perform statistical tests on data that they have collected, as well as design their own tests.*

- **Assessment:** *For this particular lesson, students will first design a hypothesis based on the procedures, they will then perform the experiment, answer their questions and evaluate their hypotheses. A rubric will be used to score their analyses.*

- **Technology:** *Although this lesson is designed for use without technology, it can easily be adapted using any apparatus available for monitoring heart rate.*

Links to NCTM 2000 Standards:

- **Content Standards**

  Number and Operations
  This lesson requires basic mathematical operations in order to determine the heart rate in beats per minute and the differences in heart rate during different conditions.

  Measurement
  This lesson requires students to monitor and measure their own heart rates and the heart rate of others.

Data Analysis and Probability
Students will be required to analyze their data in terms of their original hypothesis and the questions at the end of the experiment.

- **Process Standards**

Problem Solving
Students will use the scientific method to work through the experiment.

Reasoning and Proof
Students will be required to justify the answers to the questions with evidence from the experiment.

Links to Maryland High School Mathematics Core Learning Units:

Numbers and Operation
- Students will understand numbers ways of representing numbers, relationships among numbers and number systems.
- Students will understand the meaning of operations and how they relate to each other.
- Students will use computational tools and strategies fluently and estimate appropriately.

Functions and Algebra
- Students will use symbolic forms to represent and analyze mathematical situations and structures.

Data Analysis and Probability
- Students will pose questions and collect, organize, and represent data to answer those questions.
- Students will interpret data using methods of exploratory data analysis.
- Students will develop and evaluate inferences, predictions, and arguments that are based on data.
- Students will understand and apply basic notions of chance and probability.

Links to National Science Education Standards:

- **Unifying Concepts and Processes**
  Students will be required to explain how the procedure in this experiment applied the concepts of heart rate and the effects of physical fitness on heart rate.

- **Science as Inquiry**
  Students will develop a hypothesis and analyze their data in order to make the connection between heart rate and physical fitness.

- **Life Science**
  Students will be using and applying basic concepts about the cardiovascular system during this experiment.

- **Science in Personal and Social Perspectives**
  Students will be evaluating their own physical fitness and the results of other students in order to make observations about how physical fitness affects heart rate.

Links to Maryland High School Science Core Learning Units:

- **Concepts of Biology**
  Students will begin with an introduction to the cardiovascular system of humans. They will investigate heart volume and basic pulse monitoring. They will then move into this experiment, where they will monitor their pulse during several conditions.

Grade/Level:

This activity is appropriate for Grades 9-12.

Duration/Length:

This activity should take approximately 1-2 class periods, depending upon backgrounds and ability levels of the students.

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- Hypothesizing and analyzing data
- Heart rate and how to find their pulse

Student Outcomes:

Students will:

- test their heart rate while in a resting position, in a prone position, during and after physical exercise.
- evaluate their physical fitness using a rating system provided.
- analyze the results of the experiment to determine the effects of physical fitness on heart rate.

Materials/Resources/Printed Materials:

- Copy of procedures, including data and questions
- Watch or clock with second hand
- Access to steps

Development/Procedures:

The students will begin with reading and evaluating the procedures for the experiment then forming a hypothesis. They will then perform the experiment and analyze their data.

Assessment:

Students should present the information and their conclusions in some form of a report. The students will be scored according to the rubric included.

Extension/Follow Up:

Students may also study the effects of other factors on heart rate, such as caffeine, level of alertness, etc.

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Heart Rate and Physical Fitness

Background

One of the main concerns of the microgravity environment is the effect on the hearts of the astronauts. The circulatory system is designed to pump harder to the upper body than to the lower body. This is not necessary in microgravity. Therefore, space travelers can experience such problems as poor circulation, pooling of blood in the legs, and dizziness. The more physically fit the astronauts are, the less harm these conditions will have long-term.

As a rule, the maximum heart rate of all individuals of the same age and sex is about the same. However, the time it takes individuals to reach that maximum level while exercising varies greatly. Since physically fit people can deliver a greater volume of blood in a single cardiac cycle than unfit individuals, they can usually sustain a greater work level before reaching the maximum heart rate. Physically fit people not only have less of an increase in their heart rate during exercise, but their heart rate recovers to the resting rate more rapidly than unfit people.

In this experiment, you will evaluate your physical fitness. An arbitrary rating system will be used to "score" fitness during a variety of situations. Tests will be made while in a resting position, in a prone position, as well as during and after physical exercise.

Materials

Steps
Watch or Clock with a second hand

Procedure

1.   Each partner in a team will take turns testing and being the test subject. When being tested, your partner should record your data on your lab sheet.

2.   You will use the following steps to measure your pulse:
   - Locate your partner's pulse on their wrist or neck
   - Count the number of beats in 15 seconds, and multiply by 4

STANDING HEART RATE

3.   Stand upright for 2 minutes. Record the resulting heart rate in the Data Table.

4.   Assign fitness points based on the table below and record the value in the Data Table.

Beats/min	Points	Beats/min	Points
60-70	12	101-110	8
71-80	11	111-120	7
81-90	10	121-130	6
91-100	9	131-140	4

RECLINING HEART RATE

5. Recline on a clean surface or table for 2 minutes. Record the heart rate in the Data Table.

6. Assign fitness points based on the table below and record the value in the Data Table.

Beats/min	Points	Beats/min	Points
50-60	12	81-90	8
61-70	11	91-100	6
71-80	10	101-110	4

HEART RATE CHANGE FROM RECLINING TO STANDING

7. Quickly stand up next to the lab table, and immediately take the heart rate and record it in the Data Table.

8. Subtract the reclining heart rate value in Step 5 from this value to find the increase after standing. Locate the row corresponding to the reclining heart rate in the table below and use the heart rate increase value to obtain fitness points. Record the fitness points in the Data Table.

Reclining Rate	Heart rate increase after standing				
Beats/min	0-10	11-17	18-24	25-33	34+
50-60	12	11	10	8	6
61-70	12	10	8	6	4
71-80	11	9	8	4	2
81-90	10	8	4	2	0
91-100	8	6	2	0	0
101-110	6	4	0	0	0

STEP TEST

9.   Record the heart rate in the Data Table before performing the step test.

10.   Perform a step test using the following procedure:

- Place the right foot on the step
- Place the left foot completely on the step next to the right foot
- Place the right foot back on the floor
- Place the left foot completely on the floor next to the right foot
- This stepping cycle should take 3 seconds to complete

11.   Repeat this exercise for a total of 120 seconds (40 stepping cycles).

12.   When five steps have been completed, stop exercising long enough to record the heart rate in the Data Table. Once the heart rate has been recorded, continue the step exercise until 40 stepping cycles have been completed.

13.   Begin timing to determine the recovery rate. During the recovery period, remain standing and relatively still. Monitor the heart rate and stop timing when the heart rate returns to the value in Step 3.

14.   Assign fitness points for the recovery time based on the table below. Record the point value in the Data Table.

Time (sec)	Points
0-30	14
31-60	12
61-90	10
91-120	8

STEP TEST FOR ENDURANCE

15.   Subtract the normal standing heart rate from the heart rate after 5 steps of exercise. Record this heart rate increase in the endurance row of the Data Table.

16.   Assign fitness points based on the table below and record the value in the Data Table. Locate the row corresponding to the standing heart rate and use the heart rate increase value to obtain fitness points.

Standing Rate	Heart rate increase after exercise				
Beats/min	0-10	11-20	21-30	31-40	41+
60-70	12	12	10	8	6
71-80	12	10	8	6	4
81-90	12	10	7	4	2
91-100	10	8	6	2	0
101-110	8	6	4	1	0
111-120	8	4	2	1	0
121-130	6	2	1	0	0
131+	5	1	0	0	0

17.   Total all the fitness points recorded in the Data Table. Determine the personal fitness level using the scale below.

Low fitness_____ _Fit_____Very fit

20   30   40   50   60

Data

Condition	Rate or time	Points
Standing heart rate	Beats/min	
Reclining heart rate	Beats/min	
Reclining to standing	Beats/min	
Before step test	Beats/min	
After 5 steps	Beats/min	
Recovery rate	seconds	
Endurance	Beats/min	
		Total points:

Questions

1. How did your heart rate change after moving from a standing position to a reclining position? Is this what you expected? How do you account for this?

2. How did your heart rate change after moving from a reclining position back to a standing position? Is this what you expected? How do you account for this?

3. Predict what your heart rate might be if you had exercised for twice the length of time that you actually did. Explain.

4. How does your maximum heart rate compare to other students in your group. Is this what you expected? How do you account for this?

5. Why would athletes need to work longer and harder before their heart rates were at the maximum value?

6. How do you evaluate your physical fitness? Do you agree with the rating obtained from this experiment? Explain.

7. Current research indicates that most heart attacks occur as people get out of bed after sleep. Account for this observation.

Heart Rate and Physical Fitness Scoring Rubric

3   Hypothesis and collection and analysis of data show complete understanding of heart rate and the effects of physical fitness.

2   Hypothesis and collection and analysis of data show some understanding of heart rate and the effects of physical fitness.

1   Hypothesis and collection and analysis of data show little or no understanding of heart rate and the effects of physical fitness.